SECTION 12

HEATING, VENTILATION AND AIR CONDITIONING

ITEM **PAGE**

12.1 REFERENCES

(12A) SNAME Technical and Research Bulletin No: 4-7

(12B) SNAME Technical and Research Bulletin No: 4-16

(12C) ASHRAE Standard 62-2001, *Ventilation for Acceptable Indoor Air Quality*

(12D) SMACNA (Sheet Metal and Air Conditioning Contractors National Association) - *HVAC Duct Construction Standards, Metal and Flexible, (current edition)*

(12E) HVAC SYSTEMS – *Testing, Adjusting and Balancing Manual* (latest edition) by SMACNA

(12F) Code of Federal Regulations – 46 CFR Sub-chapter H

(12G) USCG NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 9-97, *Guide to Structural Fire Protection*

(12H) INDUSTRIAL VENTILATION 21ST EDITION by the American Conference of Governmental Industrial Hygienists

12.2 INTRODUCTION

This Section contains the Contractor Design and Provide general requirements for heating, ventilation and air conditioning (HVAC) systems serving the accommodations and auxiliary machinery spaces. The requirements for the Engine Room ventilation systems are described in Section 64 of the Technical Specification. See Section 64 of the Technical Specification for additional machinery space ventilation requirements.

For WSF Fleet-wide Standardization purposes, End No. 1 of the Vessel shall always be considered the bow, and this designation shall delineate port and starboard, fore and aft wherever they are addressed in the Technical Specification.

12.3 GENERAL

System components and equipment shall be suitable for the extreme motions, vibrations and corrosive environment imposed by a shipboard installation. Air conditioning ducts, equipment, etc. shall be suitably insulated and isolated from all structure, joiner work and supporting hangers to prevent the formation of condensation. System equipment and components shall be protected from the weather and centrally located with respect to the spaces served to reduce the length of duct, wiring, and piping to a minimum consistent with efficient design.

System equipment, ducts and trunks within Crew accommodation and Passenger areas shall be located behind bulkhead linings, suspended ceilings and in fan rooms, so as not to be visible. System ductwork and equipment shall be sized and arranged to avoid structural beam penetrations and not adversely affect ceiling heights. Fan Room arrangements shall insure effective equipment operation and include sufficient access for routine equipment inspection and maintenance such as fan lubrication, drive belt adjustment, and air filter replacement. The location of weather air intakes shall be carefully considered to avoid short circuiting with exhaust air outlets; to avoid tank vents, engine exhausts and other contamination sources; and to avoid injection of rain and sea spray.

Design of the components that supply from or exhaust air to the Lower Vehicle Deck shall meet current USCG down flooding requirements.

Particular attention shall be directed toward designing and installing systems to minimize operational airborne and structure-borne sound transmission. Acoustic dampening shall be accomplished by a combination of optimum fan selection, efficient duct design and equipment layout, insulation, sound isolation and absorption devices, and proper balancing of air flows in the various spaces.

NOTE: The Vessels shall have an integrated surveillance camera and monitioring, access control, and intrusion alarm system security system which shall require security locks and access monitoring/control. See Sections 4, 21, and 95 of the Technical Specification for system requirements.

NOTE: For the purposes of HVAC system design, the "***EOS/Workshop area***" shall be defined as including the Control Room (EOS), Chief Engineer's Office, Workshop, Engineer's Restroom, Engineer's Day Room, Stores (port and starboard), and Crew Locker Room within the same watertight boundaries of

the Control Room. The "***Pilothouse areas***" shall be defined as including the Pilothouses, the associated Master's Stateroom (or Ship's Office) and Head, the Sundeck level Unisex Restrooms, and Cleaning Gear Lockers. The "***Crew Quarters***" shall be defined as including the Crew's Staterooms, Passageway, Security Office, Cleaning Gear Locker, Linen Locker, Shower spaces, and W.C. spaces. The "***Officer Quarters***" shall be defined as including the Officer's Staterooms (except Master's Stateroom), Day Room, Emergency Generator Room, Unassigned Room, Passageway, Shower spaces, and WC spaces.

The "***Crew Quarters***" and "***Officer Quarters***" make up a "***Crew Accommodation Block***" on the Sun Deck, around the Midpoint area, Port and Stbd, of that deck.

See Section 91 of the Technical Specification for additional requirements.

12.4 DESIGN PERFORMANCE CRITERIA

All ***Pilothouse areas***, ***Crew Quarters***, ***Officer Quarters***, and ***EOS/Workshop areas*** shall be air conditioned. Other spaces shall be heated and mechanically ventilated only. Air conditioned spaces with doors opening to the weather shall have a slight positive pressure to prevent infiltration.

HVAC systems shall be designed following the methods provided in Reference (12B). Climatic data, compartment design temperatures and other assumptions to be used in the heating, ventilation and air conditioning load calculations to be provided shall be as follows:

12.4.1 Design Temperatures

The following design temperatures in **TABLES 12-1, 12-2, 12-3** shall be used by the Contractor in determining all equipment and system requirements:

TABLE 12-1
Outside Temperatures

Exterior	Heating Season (F degrees)	Cooling Season (F degrees)
Weather	15	85DB/68WB
Sea Water	44	56
Solar Radiation Decks (Single Boundary)	- -	135
Solar Radiation Bulkheads (Single Boundary)	- -	115
Solar Radiation Decks (Multiple Boundary)	- -	120
Solar Radiation Bulkheads (Multiple Boundary)	- -	105
Glass Solar Factor (Single Boundary)	- -	160 Btu/Hr/Sq Ft
Glass Solar Factor (Multiple Boundary)	- -	120 Btu/Hr/Sq Ft
Steering Gear Rooms	50	100
Tank Rooms and Voids Below LVD	40	100
Engineers Stores , Crew Locker Room/Stores	65	80
Engine Rooms	50	120
Reduction Gear Rooms	50	100
Engineer’s Operating Station	70	78DB/65WB
Engineer’s Dayroom	70	78DB/65WB
Chief Engineer’s Office	70	78DB/65WB
Engineer’s Workshop	70	78DB/65WB
Emergency Generator Room	70	100
Fan Rooms	40	100

TABLE 12-2, cont'd
Space Temperatures

Space	Heating Season (F degrees)	Cooling Season (F degrees)
Electrical Distribution Rooms	40	100
Cleaning Gear Lockers	60[1]	95
Passenger Deck Lounges	70	92
MES Stations	70	92
Passenger Restrooms	70	95
Crew Dayroom	70	92
Pursers Office	70	92
Food Vending Area and Cafeteria	70	92
Deck Crew Shelter	70	92
Pilothouses	70	78DB/65WB
Unisex Restrooms	70	78DB/65WB
Officer Staterooms	70	78DB/65WB
Dayroom	70	78DB/65WB
Navigation Bridge Deck Unassigned Room	70	78DB/65WB
Crew Staterooms	70	78DB/65WB
Navigation Bridge Deck Security Office	70	78DB/65WB
Toilet & Shower Spaces (Ventilated Areas)	70	95
Toilet & Shower Spaces (A/C Areas)	70	85
Line Stowage Locker	30	100

TABLE 12-2 Note: 1. 40F degrees for Lower and Upper Vehicle Deck Cleaning Gear Lockers.

The following **TABLE 12-3** demonstrates certain WSF standard methodology as to heating, air conditioning, and ventilating of different types of spaces to meet new Vessel and WSF Fleet-wide Standardization requirements. **TABLE 12-3** is not meant to, nor does it necessarily depict the Contractor's design and shall be used as a general guide for minimum requirements for the development of the Contractor's HVAC systems throughout the Vessel. See MATRIX OF SPACES ~ **TABLE 1B-1** in Section 1B of the Technical Specification.

TABLE 12-3
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Hold Level					
Steering Gear Room No. 1	CL	1	M	m	UH
Void No. 1	CL	1	M	m	-
Tank Room No. 1	CL	1	M	m	UH
Reduction Gear Room No. 1	CL	1	M	m	UH
Engine Room No. 1	CL	1	M	M^3	UH
Crew Locker Room / Stores	Stbd	Midpoint	AC	M	TR
Engineer's Restroom	Stbd	1	M	M	C
Engineer's Operating Station	CL	Midpoint	AC	M	TR
Chief Engineer's Office	Port	Midpoint	AC	M	TR
Engineer's Stores	Port	Midpoint	AC	M	TR
Engineer's Dayroom	Stbd	2	AC	M	TR

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Hold Level, cont'd					
Workshop	CL	2	AC	M	TR
Engine Room No. 2	CL	2	M	M^3	UH
Reduction Gear Room No. 2	CL	2	M	m	UH
Tank Room No. 2	CL	2	M	m	UH
Void No. 2	CL	2	M	m	-
Steering Gear Room No. 2	CL	2	M	m	UH
Lower Vehicle Deck					
Fire Fighting Foam Stowage	Port	1	N	N	-
Emergency Squad Locker	Stbd	1	m	M	C
Elevator No. 1	Port	1	m	M	-
Line Stowage Locker	Stbd	1	m	M	C
Fueling Equipment Locker	Port	1	N	N	-
Crew Stair Tower	Port	1	M	m	C
Electrical Dist. Room No. 10	Stbd	1	AC	M	TR

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Lower Vehicle Deck, cont'd					
Engineer's Stores	Stbd	2	-	-	-
Crew Restroom	Stbd	2	m	M	C
Elevator No. 2	Stbd	2	m	M	-
Crew Shelter	Port	2	m	M	C
Fire Fighting Foam Stowage	Stbd	2	N	N	-
Tow Bridle Stowage	Port	2	N	N	-
Upper Vehicle Deck					
Reserved Space	Stbd	1	-	-	-
Cleaning Gear Locker	Port	1	N	N	-
Deck Locker	Stbd	1	-	-	-
Deck Locker	Port	1	-	-	-
Electrical Distribution Room No. 8	Stbd	1	-	-	-
Reserved Space	Stbd	2	-	-	-
Electrical Distribution Room No. 9	Port	2	-	-	-

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Upper Vehicle Deck, cont'd					
Reserved	Stbd	2	-	-	-
Deck Locker	Stbd	2	-	-	-
Deck Locker	Port	2	-	-	-
Cleaning Gear Locker	Stbd	2	N	N	-
Paint Locker	Port	2	m	M	-
Passenger Deck					
Passenger Lounge No. 1 (includes MES Station No. 2 (Port at end of Passenger Lounge area))	CL	1	M	M	ZR
Electrical Distribution Room No. 4	Port	1	N	N	-
Stair Tower No. 1 End	Port	1	M	m	C
Stair Tower No. 1 End	Stbd	1	M	m	C
Cleaning Gear Locker	Stbd	1	m	M	-
Cleaning Gear Locker	Port	1	m	M	-
Unisex Restroom	Port	1	M	M	ZR+C

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Passenger Deck, cont'd					
Women's Restroom	Stbd	1	M	M	ZR+C
Men's Restroom	Port	1	M	M	ZR+C
Purser's Office	Stbd	1	M	m	ZR
Crew Dayroom	Port	1	M	M	ZR
Electrical Distribution Room No. 5	Stbd	1	m	M	-
Passenger Lounge No. 2, (includes MES Station No. 1 (Stbd at end of Passenger Lounge area))	CL	2	M	M	ZR
Emergency Squad Locker	Stbd	2	m	M	-
Electrical Distribution Room No. 6	Port	2	m	M	-
Cleaning Gear Locker	Stbd	2	m	M	-
Stair Tower No. 2 End	Stbd	2	M	m	C
Cafeteria and Small Galley Area	CL	2	M	M	ZR
Stair Tower No. 2 End	Port	2	M	m	C
Electrical Distribution Room No. 7	Stbd	2	N	N	-

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Sun Deck					
Cleaning Gear Locker	Stbd	1	m	M	C
Unisex Restroom	Stbd	1	AC	m	TR
Life Jacket Locker	Port	1	m	M	-
Fan Room No. 1	Stbd	1	m	M	C
Deck Locker	Stbd	1	N	N	-
SC Engineer's Stateroom	Port	1	AC	m	TR
SC Engineer's Restroom	Port	1	m	M	C
Officer's Shower	Port	1	m	M	C
Asst. Engineer's Stateroom	Port	1	AC	m	TR
Chief Mate's Stateroom	Port	1	AC	m	TR
Officer's Head	Port	1	m	M	C
Chief Engineer's Stateroom	Port	1	AC	m	TR
Fan Room No. 2	CL	1	m	M	C
Emergency Generator Room	Port	1	m[4]	M[4]	UH

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Sun Deck, cont'd					
Dayroom	Stbd	2	AC	m	TR
Crew Stateroom No. 1	Stbd	2	AC	m	TR
Crew Stateroom No. 2	Stbd	2	AC	m	TR
Linen Locker	Stbd	2	m	M	-
Cleaning Gear Locker	Stbd	2	m	M	C
Electrical Distribution Room No. 3	Port	2	m	M	C
Crew Stateroom No. 3	Stbd	2	AC	m	TR
Crew Head No. 1	Stbd	2	m	M	C
Crew Stateroom No. 4	Stbd	2	AC	m	TR
Crew Head No. 2	Stbd	2	m	M	C
Crew Stateroom No. 5	Stbd	2	AC	m	TR
Crew Shower No. 1	Stbd	2	m	M	C
Crew Stateroom No. 6	Stbd	2	AC	m	TR
Crew Shower No. 2	Stbd	2	m	M	C

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Sun Deck, cont'd					
Fan Room No.3	CL	2	m	M	C
Fan Room No. 4	Port	2	m	M	C
Deck Locker	Port	2	N	N	-
Unisex Restroom	Stbd	2	AC	m	TR
Cleaning Gear Locker	Port	2	m	M	C
Lift Jacket Locker	Stbd	2	N	N	-
Navigation Bridge Deck					
Pilothouse No. 1	CL	1	AC	M	TR
Master's Stateroom	CL	1	AC	m	TR
Master's Restroom	Stbd	1	m	M	C
Electrical Distribution Room No. 1	Stbd	1	m	M	C
Security Office	Port	1	AC	m	TR
Engine Room No.1 Plenum	Stbd	1	-	-	-
Emer. Generator Radiator Room (Navigation Bridge Deck & Above)	Port	1	m	M	-

TABLE 12-3, cont'd
Misc. Space Air Conditioning and Ventilation Requirements

Space	Port/ CL/ Stbd	Vessel End	Supply	Exhaust	Heating
Navigation Bridge Deck, cont'd					
Engine Room No.2 Plenum	Port	2	-	-	-
Unassigned Room	Stbd	2	AC	M	TR
Ship's Office Restroom	Port	2	m	M	C
Ship's Office	Stbd	2	AC	m	TR
Electrical Distribution Room No. 2	Port	2	m	M	C
Pilothouse No. 2	CL	2	AC	M	TR

KEY:

M = Mechanical supply or exhaust

AC = Air conditioning supply

m = Natural supply or exhaust due to complementary mechanical system

N = Natural supply or exhaust

TR = Terminal Reheat

ZR = Zone Reheat

C = Convector

UH = Unit Heater

TABLE 12-3 Notes: 3. Exhausts to Engine Room Uptakes.

4. An independent natural supply/mechanical exhaust system shall be provided for cooling and combustion air during Emergency Diesel Generator operation.

Overall heat transfer coefficient (U) values for decks, bulkheads and overheads shall be based on similar construction values contained in Reference (12A) and/or calculated overall heat transfer coefficient (U) values for the actual construction details proposed in the Contract Design.

Design load factors shall be based on the following:

12.4.1.1 Compartments

The cooling, heating and ventilation load requirements shall be determined by a calculation for each space prepared in accordance with Reference (12B). The format for the Heating and Cooling Load Calculation sheets shall be in accordance with Sheet 56 of Reference (12B). Compartment boundary areas for heat transmission gains or losses shall be based on molded steel dimensions. Compartment boundaries containing more than one construction type or temperature difference shall have a calculation for each condition. Compartment volumes for rate of air change calculations shall be based on finished dimensions inside joiner linings and deck coverings. For cooling season calculations, the cooling effect of adjacent spaces shall be considered only if the lower temperature is maintained by air conditioning or refrigeration equipment. For heating season calculations, the heat gain from adjacent spaces shall be considered only if the higher temperature is maintained by a heating system.

12.4.1.2 Solar Loading

Solar loading shall be calculated for compartment boundaries exposed to the sun. Where more than one (1) compartment boundary can be exposed to the sun a separate heat gain calculation shall be performed for each boundary or combination of boundaries with the greatest simultaneous gain used for determining the load. Shaded areas shall be calculated with the sun at 45 degree (45º) angle from the horizon.

12.4.1.3 Windows/Glass

Windows shall be assumed to be double-pane glass with no shades, except for the Pilothouses which shall have visor shading calculated with the sun at 45 degree (45º) angle from the horizon. Cooling season glass solar loads shall be calculated based on the area of the exposed pane and the factors contained in **TABLE 12-1**.

12.4.1.4 Infiltration

Heating season infiltration load for each Passenger Deck Lounge shall be calculated based on the interior-exterior temperature difference and a fifteen (15) minute door opening during each hour. The assumed free area for the two (2) double doors excluding passengers shall be 50 square feet with an assumed wind speed of 15 mph. Heating and cooling season infiltration loads for the Pilothouses shall be calculated in accordance with Chapter 3.6 of Reference (12B).

12.4.1.5 Lighting

Lighting heat gain shall be included in the cooling season calculation for each ventilated and air conditioned space based on the total wattage of the actual lighting fixtures installed in accordance with Chapter 3.3 of Reference (12B).

12.4.1.6 Equipment/Appliance Loads and Use Factors

Equipment heat gain shall be included in the cooling season calculation for each ventilated and air conditioned space based upon estimated heat dissipation data for the actual equipment installed.

12.4.1.7 Personnel Loads

Personnel loads shall be included in the cooling season calculations for each air conditioned space in accordance with Chapter 3.5 of Reference (12B).

12.5 SYSTEMS DESCRIPTIONS

12.5.1 General

Systems shall be complete including filters, fans, pre-heaters, cooling dehumidifying coils, heating coils, terminal reheat units, ductwork, terminals, closures, louvers, dampers, thermostats, control systems, drains, insulation (acoustic and thermal), vapor sealing and lagging, label plates, and operating instructions as necessary for satisfactory operation and performance. Systems shall be designed to prevent contamination from dissimilar spaces. Weather supply terminals shall be located so as to prevent intake from weather exhaust terminals, ship stack exhaust, or any other source of contamination. Systems shall be designed to function properly, without buildup of pressure, when weather and other normally closed doors, hatches, and similar accesses are closed. Systems shall be arranged so as to serve spaces within only one (1) Main Vertical Fire

Zone (MVZ) and to prevent duct penetrations of MVZ bulkheads. Systems serving stairway enclosures shall serve no other spaces. The ductwork systems shall be designed and sized in accordance with the equal friction method as described in Section 3, Chapter XXI of Marine Engineering published 1992 by SNAME. A constant friction loss per foot of duct shall be selected for the entire main of each system to minimize system weight and systematically reduce velocity as the air approaches interior system terminals.

Spaces requiring natural supply or exhaust ventilation may have either louvers with a net area not exceeding two (2) square feet in the lower half of "B" Class doors or balancing ducts located at deck level through "B" Class bulkheads. In spaces with "A" Class boundaries either door undercuts not exceeding ½-inch high or ducting to weather terminals with appropriate closure devices shall be provided for natural ventilation. The maximum air velocity through free openings (louvers, undercuts, etc.) shall not exceed 400 feet per minute.

Convectors shall provide heating in toilet/shower spaces, and other spaces with no mechanical supply ventilation. Unit heaters shall be provided as necessary for Engine Rooms, Gear Rooms, Tank Rooms, Void Compartments, Steering Gear Rooms, and the Emergency Generator Room to maintain the heating season temperature shown in **TABLE 12-2**.

12.5.2 Terminal Reheat Air Conditioning Systems

Single-speed constant volume terminal reheat systems consisting of a central Air Handler Unit and medium or high velocity distribution ductwork shall provide heating, ventilation, and air conditioning to the two (2) Pilothouse areas on the Navigation Bridge Deck, the Officer Stateroom area and the Crew Stateroom area on the Sun Deck, and the Engineer Operating Station/Workshop area in the Hold. The central Air Handler Unit shall provide mixing, filtering, preheat (if necessary), cooling/dehumidification, and circulation to a combination of return and outdoor air as necessary to maintain the interior temperature and humidity conditions specified in **TABLE 12-2**. The medium or high velocity distribution ductwork shall convey the conditioned air from the central Air Handler Unit to thermostatically controlled duct heating coils or terminal reheat units with integral ceiling mounted diffusing terminals located in each of the spaces served. Door louvers and ceiling mounted grilles and ductwork with silencers shall be provided as necessary for return air delivery to the central Air Handler Unit. The minimum outdoor air requirement shall be the greater of either the area exhaust system capacity or the minimum outdoor air requirement for crew occupancy, as specified in Reference (12B). The outside air terminal and duct to the central Air Handler Unit shall be sized to provide 100-percent (100%) outdoor air in the event of air conditioning condensing unit failure during the cooling season.

12.5.3 Multi-Zone Heating and Ventilation Systems

Two-speed constant volume multi-zone systems consisting of a central Air Handler Unit and medium velocity distribution ductwork arranged for three (3) zone (port, center, and starboard) reheat shall provide heating and ventilation for each Passenger Deck Lounge. A fourth reheat zone shall be provided for the No 1 End system to serve the Men's Restroom, Women's Restroom, Crew Dayroom, and Purser's Office on the Passenger Deck. The central Air Handler Unit shall provide mixing, filtering, pre-heat (if necessary) and circulation through the distribution ductwork to multiple sound attenuated plenum boxes with integral ceiling mounted diffusing terminals centrally located in the spaces served.

The system shall be designed to provide 100-percent (100%) outdoor air during the Cooling Season and a mixture of outdoor and return air during the Heating Season. Mixing dampers on the central Air Handler Unit and in the duct downstream of the return fan shall automatically control the amount of outside, return, and exhaust air to the system. The Heating Season minimum outdoor air requirement shall be the greater of either the area exhaust system capacity or the minimum outdoor air requirement for passenger occupancy as required by Reference (12B). Two-speed (Full and ⅔) system operation shall be achieved with dual winding fan motors for Heating Season or partial load conditions. Ceiling mounted grilles and ductwork with silencers shall be provided for return air delivery to the central Air Handler Unit and/or weather discharge terminal via a two-speed return fan located in the Fan Room. A thermostat shall be provided in each Passenger Deck Lounge reheat zone for automatic independent control of each reheat coil.

Ventilation requirements shall be determined as the largest of either the rate of air change or the limiting temperature rise as specified in **TABLE 12-3**.

12.5.4 Constant Volume Ventilation Systems

Constant volume mechanical supply systems consisting of a weather terminal, fan, closures, and medium velocity distribution ductwork with expanding cone or Type "E" terminals shall be provided for ventilating the Steering Gear Rooms, Hull Voids, and Tank Rooms and Reduction Gear Rooms in the Hold. Ventilation requirements shall be determined as the greater of either the rate of air change or the limiting temperature rise as specified in **TABLE 12-3**. The systems shall be designed to provide 100-percent (100%) outdoor air during the Cooling Season and Heating Season except for the Reduction Gear Rooms, which shall have provision for recirculation during the Heating Season to reduce the heating requirement.

12.5.5 Exhaust Systems

Constant volume mechanical exhaust systems consisting of weather terminal, fan, closures, and medium velocity ductwork with bell-mouth terminals or sound attenuated plenum boxes with integral ceiling mounted grilles shall be provided for spaces requiring mechanical exhaust ventilation as specified in **TABLE 12-3**. The systems shall be designed for single-speed continuous operation during both the Cooling Season and Heating Season to convey contaminated air from odor or heat producing spaces to weather while balancing the ventilation capacity of associated supply systems. Spaces located in common Main Vertical Fire Zones (MVZ) with similar design and operational characteristics shall be consolidated into single systems where practicable to minimize the number of Exhaust Systems.

12.5.6 Return Systems

Constant volume mechanical return systems consisting of weather terminal, fan, closures, mixing dampers, duct silencers, medium velocity ductwork and sound attenuated plenum boxes with integral ceiling mounted grilles shall be provided for the two (2) Multi-Zone Heating and Ventilation Systems serving the Passenger Deck Lounges. The systems shall be designed for two-speed (Full and ⅔) synchronous operation with the supply fan in the Multi-Zone Heating and Ventilation systems specified in the *Multi-Zone Heating and Ventilation Systems* Subsection in this Section of the Technical Specification to either exhaust Passenger Lounge ventilation to the weather during the Cooling Season or exhaust/return Passenger Lounge ventilation during the Heating Season.

12.6 HEATING

Vessel heating shall be provided by hot water utilizing waste heat recovered from the two (2) Main Engine Jacket Water systems. An oil-fired hot water heater shall be the supplemental heat source. An electric water heater shall be the backup heat source, but shall be sized to heat only the Pilothouse, Crew, Officer, and EOS/Workshop areas. The oil-fired and electric hot water heaters are described in Section 61 of the Technical Specification.

The hot water heating system shall be designed for 180F degree hot water with a 20F degree temperature drop across the heating coils. The hot water piping system shall be a two (2) pipe direct return type system and is described in Section 60 of the Technical Specification.

All pre-heaters, re-heaters, terminal reheat units, convectors and unit heaters shall be heated by hot water.

12.7 AIR CONDITIONING

Air conditioning shall be provided by individual direct expansion type cooling dehumidifying coils located within the central Air Handler Units and served by remote air or water cooled remote self-contained compressor/condenser units utilizing, unless approved otherwise in writing by the WSF Representative, the same EPA approved refrigerant supportable beyond at least the year 2020. The remote self-contained compressor/condenser units serving the Crew Quarters, Officer Quarters, and Pilothouse area Air Handler Units shall be air cooled. The remote self-contained compressor/condenser unit serving the EOS/Workshop areas shall be fresh water cooled. The air conditioning compressor/condenser units are described in detail in Section 65 of the Technical Specification.

The reheat schedule for each air conditioning system shall be established by a detailed analysis of the load calculations in accordance with Reference (12B) so that all air conditioned spaces can be maintained at design conditions during the Cooling and Heating Seasons. The design terminal temperature differential (difference between the air temperature at the terminal entrance and room design temperature) shall not exceed 30F degrees to minimize condensation on diffuser surfaces. The temperature selection of air leaving the cooling dehumidifying coil shall not exceed 95-percent (≤95%) relative humidity and shall remain constant during the entire cooling cycle. The effect of each space cooling load, fan heat, supply and return duct temperature rise, and outdoor air load shall be included to establish the total air conditioning load capacity in accordance with Reference (12B).

Passageways and stairways within air conditioned zones may be used for recirculation air return unless space division fire ratings exclude use of door louvers for air transfer from the spaces served, in which case return air shall be ducted directly from the spaces served to the central Air Handler Unit with appropriate fire dampers at division penetrations.

12.8 EQUIPMENT

12.8.1 General

All ventilation equipment shall be installed so as to permit access for replacement or repair, generally without removing equipment not requiring repair.

All air handling units, pipes, valves, sensors, etc., shall be clearly marked with function and direction of flow.

12.8.2 Hot Water Heater Coils

Duct heating coils shall be MARLO Type W, or equal. Heating coils mounted in air handlers shall be manufactured or approved by the air handler vendor. The coils shall be manufactured with copper headers return bends and tubes with flat copper fins designed for an operating temperature of 375F degrees and pressure of 200 psig. Each header shall have a vent and drain plug. The coil shall be constructed with multiple continuous serpentine circuits, arranged for counter-flow circulation. Full tube size return bends shall be used to minimize pipe friction. Coil frames shall be designed to support the finned core in its flooded condition, shall be at least 11 USSG galvanized steel, and shall include suitable lifting lugs and flanges for duct mounting applications. Coil fin spacing shall not exceed eight (8) fins per inch (FPI) to minimize cleaning interval requirements.

Heating coils shall be sized so that the maximum air pressure drop does not exceed ½ inch water gage at maximum design air flow.

12.8.3 Hot Water Terminal Reheat Units

Terminal reheat units shall be Type RW35-C00-25-2 as manufactured by NOVENCO, or equal to provide air distribution and heating in Crew and Officer Staterooms, Day Room, Security Office, Engineers Restroom, and Unassigned Room. Terminal reheat units shall consist of a galvanized sheet steel box with air spigot inlet connection and inorganic non-combustible sound attenuation enclosing a copper tube aluminum fin hot water coil and an integral aluminum diffuser suitable for mounting in a 300mm DANACOUSTIC ceiling. The unit shall include manual control knobs for airflow, a thermostatically controlled valve for regulating the hot water flow, and steel foundation angles for installation above joiner ceilings.

12.8.4 Hot Water Unit Heaters

Unit heaters shall be Model HS as manufactured by MODINE MANUFACTURING COMPANY, or equal. Unit heaters shall be standard size horizontal type consisting of an extended surface heating element and propeller fan enclosed in a steel casing with a threaded hanger and adjustable air deflectors. Unit Heaters shall be provided in sizes selected to maintain the minimum design temperature specified in **TABLE 12-2**. The heating element shall consist of aluminum fins and copper tubes with steel supply and return connections. The tubes shall be mechanically bonded to the collars of the aluminum fins which shall extend across the width and depth of the heating element. The heating element shall be warranted for operation at hot water pressures up to 150 psig and temperatures up to 375F degrees. The casing shall consist of 20 USSG die-formed steel front and back halves with ribs formed in the top, bottom, and both sides for added strength. Both halves shall be joined together at top and bottom utilizing the heating

element mounting screws for attachment. All casing corners shall be rounded with no breaks, and the top shall include a threaded hanger connection for unit suspension. All metal surfaces shall be treated to prevent formation of rust and finished in gray green enamel paint. The fan shall be a direct drive propeller type with aluminum blades secured to a steel hub and electric motor in accordance with NEMA Standards for continuous fan duty motor applications. A manual starter with thermal overload elements sized for the full load amperage rating of the fan motor shall be provided with the Unit Heater. A line voltage heavy duty type thermostat with contacts sized for the full load amperage of the fan motor or motor starter coil shall be provided with the Unit Heater. Space temperature shall be monitored by the HVAC System Master Controller.

12.8.5 Hot Water Convectors

Convectors shall be STERLING Type SW-A, or equal, bulkhead hung Slope-Top cabinets constructed of minimum 16 USSG Type 304 stainless steel. The cabinet shall be suitably braced and reinforced where necessary for stiffness and accurately fitted to prevent air leakage. The front shall wrap around the sides of the cabinet and fasten with Allen-head screws. Venetian type air outlet louvers shall be provided in the top face of the front panel with air inlet through the open bottom of the cabinet. The back panel shall be provided with holes for bulkhead mounting. After fabrication cabinets shall be thoroughly cleaned and provided with a high quality baked enamel prime coat. Heating elements shall be non-ferrous consisting of ½ inch diameter copper tubing and 0.010 inch thick aluminum plate fins with fully flanged collars. The tubes shall be expanded mechanically into fin collars to form a permanent thermal bond. The fins shall be protected front and back by formed shield plates extending the entire length of the element. Headers shall be cast brass and provided with bottom threaded piping connections. The heating elements shall be tested by manufacturer at 100 PSI air pressure under water and rated in accordance with Commercial Standard CS 140-147 as developed by the National Bureau of Standards and the U.S. Department of Commerce.

12.8.6 Air Handlers and Fans

12.8.6.1 General

Fan type shall be either axial or centrifugal in standard sizes conforming to Air Movement and Control Association, Inc (AMCA) requirements. Fan size selection shall be based on optimum mechanical efficiency and minimum noise production for the calculated capacity and pressure characteristics of each system with air density at 70F degrees and sea level. Fan selections having less than optimum mechanical efficiency or noise characteristics shall be acceptable in conditions where limited installation space would make a slightly smaller fan the better choice for optimum equipment arrangement and performance. Fan performance shall be based on tests

and procedures conducted in accordance with AMCA Publication 211 and shall comply with the requirements of the AMCA Certified Ratings Program. The fan manufacturer shall be certified to ISO 9001 quality system standards.

Fans serving Battery Rooms, Fueling Station, paint Lockers, and flammable storerooms shall be spark-proof and motors explosion-proof.

Fans not mounted in air handlers shall be properly supported from the Vessel's structure with resilient mounts. Fans shall be equipped with fire resistant, flexible duct connections. Electric power to all fan motors is provided in Section 90 of the Technical Specification.

The Contractor shall submit to the WSF Representative, for approval, certified dimensional drawings and performance curves for each size fan and motor set. The performance curves shall illustrate the relationship of air capacity (cfm) to power input (kW), brake horsepower, static pressure, total pressure, total fan efficiency, and sound decibel rating at the specified fan speed. Performance curves shall be based on tests made in accordance with AMCA Publication 211 and the requirements of the AMCA Certified Ratings Program.

Each fan shall be equipped with a nameplate attached to the fan housing in an easily readable location, listing the system served, fan airflow capacity in cubic feet per minute (cfm) fan static and total pressure in inches water gage (GI) fan size, fan speed, fan brake horsepower, motor speed, and motor horsepower.

Each fan housing shall be clearly marked with arrows indicating rotation and direction of flow.

Fan brake horsepower shall not exceed the motor horsepower between free delivery and 50-percent (50%) of rated CFM at rpm shown. Motors shall comply with the requirements of Section 91 of the Technical Specification. Fan motors shall be rated for the system flow at 40C degrees. Motors exposed to high ambient temperature, such as those located in the stacks, shall be appropriately rated.

Each fan assembly shall receive a high pressure cleaning after fabrication followed by an application of one (1) coat of primer and one (1) coat of enamel paint having a minimum dry film thickness (DFT) of 2.5 mils by the fan manufacturer before being shipped.

12.8.6.2 Air Handlers

Central air handlers, PACE or equal, shall be complete with unit casing, filter box section, fan section, heating coil section, cooling coil section, and mixing box section.

Air handler casings shall be airtight, minimum 16 USSG galvanized steel double-skin design, with a one (1) inch layer of mineral wool sandwiched between the steel panels. The case shall be designed to withstand an internal pressure or vacuum of at least 1.25 (1¼) times maximum fan static pressure. Interior surfaces shall be smooth and easy to keep clean. Interior components shall be mounted such that they can be withdrawn for inspection and service. Filter cassettes shall be mounted on slide rails for ease of changing filters.

Air handler design shall be such that all equipment can be inspected and serviced from one (1) side of the air handler. Inspection panels shall be sturdy but light, hinged on one side with a locking handle on the other side.

The fan, drive and motor shall be mounted on a common base, completely isolated within the cabinet by factory installed vibration isolation mounts and a neoprene-coated flexible connection at the fan outlet. Fans shall meet specifications for centrifugal fans in this Section.

Direct expansion cooling coils shall be manufactured with copper headers, copper tubes and flat copper fins and silver soldered. The coil shall be constructed with multiple continuous serpentine circuits arranged for counter-flow circulation. The headers shall be sized properly to provide uniform distribution and proper refrigerant velocities to all coil circuits. The liquid and suction connections shall be on the same side of the coil. Coil frames shall be designed to support the finned core in its flooded condition, shall be at least 11 USSG galvanized steel, and shall include suitable lifting lugs. The chiller coil shall be equipped with a deep stainless steel condensate drain tray with dual drain connections. The drain tray shall discharge through a non-return valve. Drains shall be led to the nearest deck drain.

12.8.6.3 Axial Fans

Axial fans shall be direct drive type JM AEROFOIL as manufactured by AMERICAN FAN COMPANY & WOODS U.S. DIVISION, or equal. Fan casings shall be fabricated from heavy gauge steel with spun flanges, continuously welded seams and stringent tolerance for roundness to insure proper blade tip clearance and optimal performance. Motor supports shall be fabricated from heavy gauge steel and bolted to the fan casing to insure the concentricity of the motor to the fan casing.

Axial fans shall be ordered with either mounting feet or suspension clips as appropriate for each installation. Axial fans with ducted connections shall be ordered with flexible connectors and companion flanges. Axial fans with non-ducted inlets or discharges shall be ordered with either inlet bells or outlet cones as appropriate. Silencers shall be ordered with axial fans as required to meet the noise levels specified in Section 1 of the Technical Specification.

Impellers shall consist of high pressure die cast aluminum airfoil blades, hub, and clamp plate with fully adjustable blade pitch angle. All impeller components shall be X-Ray examined to ASTM E155 prior to machining to insure casting integrity and quality. Impellers shall be statically and dynamically balanced as a component and then further balanced as a fan assembly to minimize vibration levels and assure smooth operation.

Motors shall be cast iron totally enclosed air over frame with pad mounted design suitable for horizontal through vertical operation. Motors shall be three (3) phase premium efficiency or single (1) phase standard efficiency with 1.15 service factor and Class F insulation. All motor efficiency testing and labeling shall be in accordance with NEMA MG1-12.53 standard. Bearings shall be, sealed, anti-friction ball or roller type with 30,000 hours L-10 life minimum. A cast iron electrical conduit box shall be provided on the fan casing exterior with an airtight conduit connection through the fan casing to the motor.

Fan casing minimum thickness shall be as specified in **TABLE 12-4**.

TABLE 12-4
Axial Fan Casing Thickness Specification

Axial Fan Size	Minimum Casing Thickness (inches)
15 inch diameter and smaller	$^1/_8$
16 inch through 28 inch diameter	$^3/_{16}$
29 inch diameter and larger	$^1/_4$

The entire fan casing, vanes and supports, shall be hot-dip galvanized or electro-plated with zinc. Electro-plating shall have a minimum thickness of 0.0005 inch.

12.8.6.4 Centrifugal Fans

Centrifugal fans shall be side inlet type in accordance with AMCA Publication 201-90 and may be either direct drive (Arrangement 4) or belt drive (Arrangement 9) as is appropriate to the application. Belt drives shall be designed for 150-percent (150%) of motor capacity. Fan motors shall be totally enclosed, fan cooled.

Fans with eighteen (18) inch diameter and larger impellers shall be type BCA as manufactured by AMERICAN FAN COMPANY & WOODS U.S. DIVISION, or equal, consisting of a heavy gauge steel housing, frame, impeller, shaft, motor, and drive assembly as necessary for a complete operational unit. The fan housing shall be continuously welded with suitable bracing to prevent vibration or pulsation, a drilled outlet flange and a tapered spun, aerodynamically designed inlet cone with a drilled inlet flange. The impeller shall be a non-overloading airfoil type fabricated from high strength steel with airfoil blades continuously welded to the impeller flange and back plate. The impeller shaft shall be AISI 1141 solid cold rolled steel, accurately turned, ground, polished, and ring gauged for accuracy. Bearings shall be heavy duty, sealed, anti-friction ball or roller self-aligning pillow block type selected for a minimum average bearing life in excess of 200,000 hours at the maximum fan speed.

Fans with twelve (12) inch up to eighteen (18) inch diameter impellers shall be type BCS as manufactured by AMERICAN FAN COMPANY & WOODS U.S. DIVISION, or equal, consisting of a heavy gauge steel housing, frame, impeller, shaft, motor, and drive assembly as necessary for a complete operational unit. The fan housing shall be continuously welded with suitable bracing to prevent vibration or pulsation, a drilled outlet flange and a tapered spun, aerodynamically designed inlet cone with a drilled inlet flange. The impeller shall be a non-overloading backward curved type fabricated from high strength steel with backward curved blades continuously welded to the impeller flange and back plate. The impeller shaft shall be AISI 1141 solid cold rolled steel, accurately turned, ground, polished, and ring gauged for accuracy. Bearings shall be heavy duty, sealed, anti-friction ball or roller self-aligning pillow block type selected for a minimum average bearing life in excess of 200,000 hours at the maximum fan speed.

Fans with impellers less than twelve (12) inch diameter shall be either type SMD, SMB, or SC as manufactured by AMERICAN FAN COMPANY & WOODS U.S. DIVISION, or equal. SMD and SMB type shall consist of a heavy gauge steel housing, base, impeller, shaft, motor, and drive assembly as necessary for a complete operational unit. The fan housing shall be continuously welded with suitable bracing to prevent vibration or pulsation, a drilled outlet flange and a tapered spun, aerodynamically designed inlet cone with a drilled inlet flange. The SC type shall consist of a cast aluminum split case housing with a round slip fit inlet and discharge,

impeller, and motor as necessary for a complete operational unit. The impeller shall be a forward curve type fabricated from high strength steel with forward curve blades stamped to the impeller flange and back plate. All forward curve impellers shall be epoxy coated after fabrication.

The minimum USSG or thickness of sheet steel to be used for pedestal motor mounted fans is **TABLE 12-5** below:

TABLE 12-5
Centrifugal Fan Casing Thickness Specification

Centrifugal Fan Impeller Diameter	Scroll Sheet	Side Sheet	Blade	Impeller Back Plate	Motor Base
Under 8 inches	Cast AL	Cast AL	14 GA	14 GA	N/A
8 to 12 inches	14 GA	14 GA	14 GA	14 GA	12 GA
12 to 15 inches	14 GA	12 GA	14 GA	12 GA	$^{3}/_{16}$ inch
16 to 20 inches	12 GA	12 GA	12 GA	12 GA	¼ inch
22 to 30 inches	12 GA	10 GA	10 GA	10 GA	¼ inch
Over 30 inches	12 GA	10 GA	10 GA	7 GA	¼ inch

Wheels shall be removable from the side of the housing. On impeller diameter sizes of sixteen (16) inches and larger, wheels shall be removable from the motor side of the housing, and the motor, motor base, housing back plate, and wheel shall be removable without disturbing duct connections on the fan inlet and outlet.

Fan housing shall be convertible to at least eight (8) positions of discharge 45 degrees (45°) apart.

A hand hole with bolted-on cover plate, located at a point 45 degrees (45°) from the bottom, shall be provided on impeller diameter sizes thirteen (≥13) inches and larger.

On impeller diameter sizes thirteen (≥13) inches and larger, except on bottom horizontal discharge, a ½-inch drain cock shall be provided at the lowest point of the

scroll. A boss, welded to the scroll, shall be drilled and tapped to receive the drain cock.

12.8.7 Terminals; Diffusers, Grilles, and Louvers

All air terminals shall meet United States Public Health Service (USPHS) requirements. All supply terminals, except directional types, shall be capable of properly ventilating the space involved without creating drafts.

Diffusers and grilles shall be selected on the basis of Noise Criteria (NC) Curves acoustical design criteria. Diffusers and grilles shall be selected to meet the criteria of:

- NC-35 or less for Passenger Lounges and Crew accommodation spaces
- NC-40 or less for Offices and food preparation areas
- NC-45 or less for Workshops

Diffusers, sound attenuated plenum boxes, return and exhaust grilles shall fit the ceiling system or joiner work as appropriate and shall harmonize with the decor of the space as approved by WSF. Select appropriate throw pattern in accordance with the manufacturer's literature.

Supply terminals for Passenger Lounges, Restrooms, Cafeteria, Small Galley, Crew Day Room, Pursers Office, Engineer Operating Station, Chief Engineer's Office, Day Room, Workshop, Pilothouses, Master's Stateroom, and Ship's Office shall be Type "PKA" diffuser with a Type "MBA" supply box as manufactured by NOVENCO, or equal. The supply terminal shall consist of a galvanized sheet steel box with an air spigot inlet connection and inorganic non-combustible sound attenuation with an integral aluminum outlet diffuser suitable for mounting in a 300mm DANACOUSTIC, or equal, ceiling. The supply terminal shall include an air capacity regulating device.

Supply terminals for Engine Rooms and Reduction Gear Rooms shall be Type "E" adjustable blast terminals with volume damper and discharge cone with ½-inch mesh screen as manufactured by SPIRAL METALS CORPORATION, or equal.

Supply terminals for Tank Rooms, Voids, Steering Gear Rooms and Storerooms shall be expanding cone Type "JA" with ½-inch mesh screen as manufactured by JUNIPER INDUSTIRES INC, or equal.

Exhaust terminals for Passenger Restrooms shall be Type "PKA" diffuser with a Type "MBA" supply box as manufactured by NOVENCO, or equal. The exhaust terminal shall consist of a galvanized sheet steel box with an air spigot outlet connection and inorganic non-combustible sound attenuation with an integral aluminum inlet diffuser suitable for mounting in a 300mm DANACOUSTIC, or equal, ceiling. The exhaust terminal shall include a air capacity regulating device.

Exhaust terminals for Crew and Officers Toilets and Showers shall be Type C00-25 diffuser with a Type "EX" exhaust box as manufactured by NOVENCO, or equal. The exhaust terminal shall consist of a galvanized sheet steel box with an air spigot outlet connection and inorganic non-combustible sound attenuation with an integral aluminum inlet diffuser suitable for mounting in a 300mm DANACOUSTIC, or equal, ceiling. The exhaust terminal shall include a air capacity regulating device.

Exhaust terminals for Tank Rooms, Voids, Steering Gear Rooms, Storerooms, and compartments without joiner ceilings shall be Type "K" bellmouths with ½-inch mesh screen as manufactured by SPIRAL METALS CORPORATION, or equal.

Return grilles for the Passenger Lounges, Officer and Crew Stateroom Passageways, Pilot Houses and exhaust grilles for the Small Galley shall be Type "F20" as manufactured by NOVENCO, or equal.

A stainless steel canopy exhaust hood conforming to **Figure VS-99-03** in Reference (12H) shall be provided over the electric range in the Engineer Day Room, Crew Day Room, and Day Room.

A stainless steel flanged welding hood as set forth in Sections 64 and 80 of the Technical Specification shall be provided for the Welding Table in Engine Room No 1.

Weather louvers and associated external ductwork and fasteners shall be manufactured from Type 316L (Type 316 for fasteners) stainless steel. Unless approved otherwise in writing by the WSF Representative, the coaming shall be of sufficient depth to include the louver blades and screen frame. The blades shall be parallel and set 45 degrees from the horizontal. Blades shall be flanged down on the weather side and up on the interior side, installed three (3) inches apart and overlap at least ½ inch. The coaming and blades shall be no less than ⅛ inch thick. Louvers shall be provided with Type 316 stainless steel screens on the inside, arranged for easy access for cleaning. The screen mesh shall be as set forth in the *Weather Openings* Subsection in this Section of the Technical Specification. Louvers shall be sized to account for the loss of cross sectional area attributable to the screens.

Weather terminals shall be, to the greatest extent possible, of the self-draining air lift type to keep out water and spray from weather and deck washdown. ***For purposes of this requirement, all terminals on the Vehicle Decks shall be considered weather terminals***.

12.8.8 Balancing Dampers

Provide adjustable manual dampers in all supply and exhaust branch ducts except those serving terminals that have integral flow adjustment devices. Balancing dampers in ducts shall be of the butterfly type with locking indicator, located as remote from the terminals as practicable with clear and easy access.

12.8.9 Fire Dampers

Fire dampers shall be provided at each duct penetration through an "A" Class compartment boundary as required to comply with the regulatory requirements. Regulatory requirements notwithstanding, provide HALTON FDB2 Marine Fire Dampers, or equal, installed in the supply and exhaust ducting or plenums for the Engine Rooms, Reduction Gear Rooms, and EOS HVAC system. These dampers shall be controlled as described in the *Fire Damper Controls* Subsection in this Section of the Technical Specification.

An automatic/manual fire damper shall be provided adjacent to each duct penetration through main vertical zone (MVZ) bulkheads. Provide HALTON FDB2 Marine Fire Damper, or equal, with damper position indication switches, factory provided with the damper assemblies. The duct between the bulkhead and the damper shall meet the applicable bulkhead requirements. The damper shall be fitted on at least one (1) side of the bulkhead with a visible indicator showing whether the damper is in the open or closed position. The indicator may be connected to the manual operating device rather than the damper blade so that it might show as being open when it had automatically closed, but could never be open if the indicator showed it to be closed. The damper shall be capable of being manually closed from both sides of the bulkhead. The operating positions for the damper shall be marked as required by regulatory requirements.

A damper positioning mechanism shall be provided for each damper which is accessible without removal of any access panel, capable of both opening and closing of the damper. For automatic fire dampers, provide easy access through the joiner work or ceiling system and a hinged or quick disconnect access in the duct work to reset the fusible link.

Damper controls shall be grouped as practicable for efficient, quick operation.

12.8.10 Air Filters

Air filters shall be provided in all air conditioning and re-circulating ventilation systems. The filters shall meet ASHRAE Standard 52-75 Class G85 and shall be UL listed as Class 1, unless otherwise specified. Standard replaceable filter sizes shall be 24 inches × 24 inches × 2 inches (nominal)).

Provide a differential pressure sensor at each air filter location to monitor filter resistance in accordance with the control subsection of the Technical Specification..

Provide hinged doors with lockable latches for access to air filters inside plenums. The plenums and access shall be of ample size to facilitate replacement of filter media.

Air filters shall be selected for a maximum velocity of 500 feet per minute (fpm) based on full speed system airflow capacity. Preferred air velocity through filters is 350 feet per minute.

Filters shall be protected against dirt during construction and shall not be used until the system is thoroughly cleaned. Filters shall be installed before the systems to which they connect are operated for any purpose. After all system adjustments are completed and just prior to Vessel delivery the contractor shall replace all air filters and provide two (2) complete sets of replacement filters into the designated storage area.

12.9 DUCTWORK

12.9.1 Air Velocities

Maximum air velocities are provided in **TABLE 12-6** below. The noise level contributed by the ventilation system shall be established to meet the maximum compartment noise level specified in Section 102 of the Technical Specification and shall not be obtrusive in any space served. Corresponding decreases in these velocities may be required to meet noise level criteria. Air velocities are specified in feet per minute (fpm).

TABLE 12-6
Maximum Air Velocity Specifications

Type/Description	Maximum Velocity	Notes/Restrictions
Terminal Reheat Air Conditioning Systems	5,000	Use acoustical treatment to confine and absorb vibration and airborne noise to meet limits of Section 102 of the Technical Specification.
Multi-Zone Re-heat Air Conditioning Systems	2,500	
Mechanical Ventilation Duct Systems (Supply and/or Exhaust)	3,500	Machinery space systems
Mechanical Ventilation Duct Systems (Supply and/or Exhaust)	2,500	General purpose systems
Mechanical Ventilation Duct Systems (Supply and/or Exhaust)	2,000	Systems serving office and Passenger spaces
Natural Ducts Serving Mechanically Ventilated Spaces	1,000	Air flow rates up to 4,000 cfm
Natural Ducts Serving Mechanically Ventilated Spaces	1,250	For air flow rates between 4,000 and 6,000 cfm
Natural Ducts Serving Mechanically Ventilated Spaces	1,500	For air flow rates of more than 6,000 cfm and gooseneck weather terminals
Natural Ducts Serving Naturally Ventilated Spaces	800	--
Cooling Coils	500	Face Velocity.
Heating Coils	800	Face Velocity.
Weather louvers and air lifts	1,000	Based on free area.
Air Filters	500	Nominal face velocity shall be 350 fpm

12.9.2 Construction

Ducting shall be constructed in accordance with Reference (12D), except as modified in this Section of the Technical Specification.

All ducts shall be airtight. Trunks, ducts, covers, louvers, etc., exposed to the weather shall be watertight. Built-in trunk construction shall not be used for ducts having less than one (1) square foot cross section area, or less than nine (9) inches minimum dimension.

All ducts shall be smooth inside with no protruding edges. Break large panels to prevent panting. Damper blades, linkages, splitter vanes and other parts exposed to air flow shall be rigid and firmly secured.

Sheet metal ducts shall be made with either riveted or hooked seams sealed with hot solder or USCG approved fire resistive high velocity duct sealer, or welded seams.

Overhead ducting shall be installed in the space between the joiner ceiling and the deck above.

Install ductwork as close to deck beams and structure as practicable. All ductwork shall be properly supported from ship's structure, and shall comply with clearance and access requirements of Sections 1 and 1B of the Technical Specification.

Ductwork penetrations through interior “A-Class” steel decks and bulkheads shall be either round, flat-oval, or rectangular with radius corners and located to avoid structural stiffening members. Flanged coamings at least twenty four (24) inches long and fabricated from 11 USSG galvanized steel (minimum) shall be welded at midpoint to the deck or bulkhead penetrated.

Weather area ductwork from all stainless steel weather louvers, screens, and/or terminals, and extending back twelve (12) LF shall be fabricated of Type 316 stainless steel materials in lieu of galvanized steel. Ductwork plenums associated with these installations shall be provided with dual (fore & aft) drains piped down to within three (3) inches of the deck or curb. Piping materials for such installations shall be Type 316 stainless steel, sized appropriately for the plenum, but in no cases shall drain piping be less than one (1) inch IPS.

All joints in the ductwork shall be sealed airtight with an approved fire resistant, high velocity duct sealer. Duct sections between flange joints shall not exceed eight (8) feet in length.

All ducts shall be clearly marked as to "system," with function (i.e., "Supply,", "Return", or "Exhaust") and direction of flow at least once in **every** compartment, at both sides of any bulkhead penetration, at least once every fourteen (14) feet, and as set forth in Section 24 of the Technical Specification.

Provide duct access openings to clean all ducts and equipment. Removable duct sections may be substituted where necessary. Provide bolted access for both sides of each duct heating coil, and upstream side of each vane turn or splitter, and near each fire damper. Provide hinged doors at the inlet and discharge side of each axial fan, both sides of cooling coils and the entrance to plenums for servicing filters.

Round or flat-oval spools shall be used for penetrations of beams, girders, or other strength members. Beam or girder penetrations shall be as near the neutral axis of the member as possible with suitable strength compensation in the form of sleeves or doublers provided as required.

All ducts that must pass over electrical equipment shall be made watertight and insulated to prevent condensation from dripping upon electrical equipment. Ducts **shall not** be located above electrical equipment.

Sufficient flange or approved clamp connections shall be provided for making ducts portable where needed for servicing or shipping equipment. Slip joints **shall not** be used.

Elbows in ducts and trunks shall be designed with a throat radius equal to the duct diameter or duct width in the plane of the bend. Where throat radius must be less than ½ standard, concentric radius turning vanes shall be provided to minimize air turbulence and noise. Where duct turns are required upstream of axial fans, duct heating coils, or supply system branch takeoffs, radius elbows may be used provided the minimum length of straight duct between the turn and the fitting is equal to the duct dimension in the plan of the bend times:

Two (2)	for 30 degree elbows
Three (3)	for 45 degree elbows
Four (4)	for 60 degree elbows
Five (5)	for 90 degree elbows

Radius elbows with splitters may be used provided the minimum length of straight duct between the turn and the fitting is equal to the dimension between the longest splitter and the heel of the elbow times:

Two (2)	for 30 degree elbows
Three (3)	for 45 degree elbows
Four (4)	for 60 degree elbows
Five (5)	for 90 degree elbows

Vaned turns shall be used where the length of straight duct between the turn and the fitting is less than that required above.

Transition ducts shall be as symmetrical as possible with side tapers not to exceed 20 degrees for converging and 7½ degrees for diverging based on airflow direction. Where diverging side taper exceeds 10 degrees splitters shall be fitted to reduce the expansion angle.

Circular duct shall be used wherever practicable. Where rectangular or flat-oval ducts are used, the ratio of the large to the small dimension shall not exceed 3.5 to 1.0.

For high velocity duct systems (velocities greater than 3,000 FPM), the ducting shall be double walled, pre-insulated circular or flat oval duct.

Ducts in fan rooms and in void spaces shall be suitably marked for service and direction of flow as set forth in Section 24 of the Technical Specification.

Low points in the ductwork shall be provided with pet cock drains.

12.9.3 Duct Thickness

Ductwork shall be fabricated from galvanized steel in accordance with **TABLE 12-7** below, with shapes conforming to ASTM F1005 and reinforcement conforming to applicable construction standards contained in Reference (12D).

TABLE 12-7
Duct Thickness Specifications

Duct Description/Size (Diameter for round duct, maximum dimension for rectangular duct)	Wall Thickness (minimum)
All vertical exposed ducts	16 USSG
Horizontal or concealed vertical ducts over 30 inches	16 USSG
Machinery space ducts	16 USSG
Horizontal or concealed vertical ducts between 18½ and 30 inches	18 USSG
Horizontal or concealed vertical ducts between 12½ and 18 inches	20 USSG
Horizontal or concealed vertical ducts up to 12 inches	22 USSG
Factory fabricated spiral duct (round or flat oval) up to 24 inches	22 USSG
Trunks and ducts exposed to weather, in shops or exposed on the Vehicle Decks	11 USSG

Note: Where the duct wall forms a "fire boundary," the duct shall be constructed to meet bulkhead requirements. Thickness shall meet USCG fire regulations.

12.9.4 Weather Openings

Weather openings through Vessel structure shall be either round, flat oval, or rectangular with minimum 3-inch radius corners and fitted with welded Type 316 stainless steel coamings of sufficient length to attach hinged watertight covers or other means of closure. Airlifts behind weather openings shall be welded steel construction equal to the structure penetrated with radius heels to promote self draining and reduce pressure loss. Type 316 stainless steel ½ inch × ½ inch × 0.108" thick wire mesh screens and frames shall be provided on all vent weather openings. Louvers shall be provided on all vent weather openings where airlifts or other suitable water exclusion features cannot be utilized. Airlifts are the preferred method of water exclusion.

12.10 CONTROLS

All Work of this Subsection shall be coordinated and furnished by a single HVAC Control System (HCS) Contractor. The Ventilation Control System shall be produced using one (1) manufacturer's materials, parts, and devices to the greatest extent possible.

All HVAC system controls shall be electronic. The HVAC systems shall be controlled from a single electronic master controller. The master controller shall control the air conditioning systems, all central air handler units all duct heaters and change-over dampers and all fans serving the Engine Rooms, Reduction Gear Rooms, Tank Rooms, Engineer's Store Rooms, Engineer's Workshop, and exhaust from the Officers and Crew Quarters. The control system shall seamlessly interface with designated lighting control and other selected loads over a fiber optic network after conversion from copper, integrated with the HCS using the Fiber Optic Ethernet Protocol as set forth in the *SQUARE D POWERLINK® LIGHTING AND REMOTE* CONTROL SYSTEM Subsection in Section 92 of the Technical Specification. Provide graphical lighting control software at HCS workstations as specified in Section 92 of the Technical Specification.

The HVAC Control System Contractor shall be a primary manufacturer-owned, system JOHNSON CONTROLS, or equal, with main or branch office that is regularly engaged in the engineering, programming, installation, training, and service of HCS Systems of similar size, scope and complexity to the HCS specified in this Technical Specification.

The HCS Contractor shall have a branch facility within a fifty (50) mile radius of the WSF Pier 52 facility supplying complete spare parts, maintenance and support services on a 24 hour, 7-day-a-week basis. This same main or branch facility shall provide the work for this task.

The Work of this Section shall be scheduled, coordinated, and interfaced with the associated Contract Work of the Shipyard.

The HCS shall be a complete system designed for use on dedicated Ethernet networks. Primary controllers shall be located in areas designated in the approved Shipyard Contractor's design, and similar shall be fully Ethernet compatible devices that mount and communicate directly on the Ethernet infrastructure. All points of user interface shall be at an operator workstation in the EOS.

The HCS Work shall consist of the provision of all technical labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, and labeling, engineering, calibration, documentation, samples, submittals, testing, verification, training services, permits and licenses, , services, and items as specified

in these documents which are required for the complete, fully functional and commissioned HCS.

In addition to the one (1) year labor and material warranty by the Shipyard, provide an additional material only warranty of three (3) years from the date of each Vessel delivery to WSF.

12.10.1 Operator Workstations

The Operator Workstations (OWS) shall provide the primary means of communication with the HCS and shall be used for operations, engineering, management, audit, reports and other related functions. The OWS shall be located in the EOS.

The OWS shall consist of one (1) desktop mini-tower unit manufactured by DELL™, or equal, properly configured to meet the intent of the specified software requirements. Software and license shall be provided for a second computer installation in addition to the OWS system.

The EOS OWS shall, at a minimum, consist of: 2.0 GHz Pentium 4 processor with 512MB of RAM, Microsoft® Windows® XP Professional Operating System, 10MBPS or 10/100MBPS Ethernet NIC, 80 GB Hard drive, Read/Write CD-ROM 32X performance, Ports – (2) Serial and (1) parallel, (2) USB ports Full ASCII keyboard and digital Mouse pointing device, full color, flat screen VDU display unit, minimum 20-inch diagonal screen, minimum 1280 × 1024 resolution, 0.26 or better dot pitch and minimum 72 Hz refresh rate. The printer utilized shall be shared with a third party application.

Provide an EXOR, part number eTOP39, or equal, dimmable touch screen in each pilothouse for remote control of all electrically operated ventilation fire dampers, exclusive of hold deck spaces. Program the touch screens with HCS-supplied software to create mimic screens and fire damper release zones. Final design of the screen graphics, zone groupings, and touch screen locations shall be subject to approval by the WSF Representative. The touch screen panels shall operate over the *SQUARE D POWERLINK*® Ethernet Fiber Optic Network.

12.10.2 Operator Interface

12.10.2.1 General

The HCS Operator Interface shall be user friendly, readily understood and make maximum use of colors, graphics, icons, embedded images, animation, text based

information and data visualization techniques to enhance and simplify the use and understanding of HCS.

User access to the HCS shall be protected by flexible and WSF re-definable software-based password access protection. Password protection shall be multi-level to accommodate the varied access requirements of the different user groups. Provide the means to define unique access privileges for each individual authorized user.

The OWS shall incorporate comprehensive support for functions including: User access for information retrieval and control command execution, monitoring and reporting, alarm, non-normal, and return to normal condition annunciation, selective operator override and other control actions, information archiving, manipulation, formatting, display and reporting, on-line access to user "HELP" menus, on-line access to current HCS as-built records and documentation, means for the controlled re-programming, re-configuration of HCS operation and for the manipulation of HCS database information in compliance with the prevailing codes, approvals and regulations for individual HCS applications.

Provide HCS reports and displays making maximized use of simple English language descriptions and readily understood icons, symbols, acronyms, abbreviations (as set forth in Section 100 of the Technical Specification) and the like to assist user understanding and interpretation. All text naming conventions shall be consistent in their use and application throughout the HCS.

The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected.

It shall be possible for the operator to divide the display area within a single window into multiple display panels. The content of each display panel can be any of the standard summaries and graphics provided by the system. Provide each display panel with minimize, maximize, and close icons.

Provide legal copies of software licenses for all software residing in the HCS system for each Vessel and transfer these licenses to WSF prior to completion.

The HCS shall support up to four (4) concurrent users.

12.10.2.2 Alarms

Alarms shall be routed directly from primary application controllers to the OWS. The alarm portion of the OWS software shall provide the following functions: Log, date and time of alarm occurrence, generate a "Pop-Up" window with audible alarm informing a user that an alarm has been received, allow a user with the appropriate security level to acknowledge, temporarily silence, or discard an alarm, provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken and a time/date stamp. Any attribute of any object in the system may be designated to report an alarm.

The HCS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.

12.10.2.3 Reports

Reports shall be generated and directed user interface displays, printers, or archive at the user's option. The system shall provide the following reports: All points in the HCS, all points in each HCS application, all points in a user-defined group of points, all points currently in alarm in an HCS application, all points locked out in an HCS application, HCS diagnostic and system status reports, all user defined and adjustable variables, schedules, interlocks and the like, run time summaries, trend logs and maintenance reports.

Provide for the generation by the user of custom reports.

12.10.2.4 Dynamic Color Graphics

1. An unlimited number of graphic displays shall be able to be generated.

2. Values of real time attributes displayed on the graphics shall be dynamic and updated on the displays.

3. The graphic displays shall be able to display and provide animation based on real-time HCS data that is acquired, derived, or entered.

4. The user shall be able to change values and states in system controlled equipment directly from the graphic display.

5. Provide a graphic editing tool that allows for the creation and editing of graphic files. It shall be possible to edit the graphics directly while they are on line, or at an off line location for later downloading to the primary controllers.

6. HCS system shall be provided with a complete user expandable symbol library containing all of the basic symbols used to represent components of a typical HCS system. Implementing these symbols in a graphic shall involve dragging and dropping them from the library to the graphic.

7. Provide a color graphic display for the entire Vessel, each deck level plan, each HVAC zone, each system, each fire/smoke control zone, each controller, color coded to indicate zone values and status with all input/output points.

8. User shall access the various system schematics and floor plans via a graphical penetration scheme and/or menu selection. User shall penetrate from Vessel graphic, to deck plan to associated HVAC system and zone graphic.

12.10.2.5 Historical Trending and Data Collection

Trend and store point history data for all user selected HCS points and values. Trend data shall be stored in a manner that allows custom queries and reports using industry-standard software tools.

12.10.2.6 Downloading and Uploading

Provide the capability to generate HCS software-based sequences, database items, associated operational definition information and user-required revisions at any OWS, and the means to download same to the associated controller. Provide the capability to upload HCS operating software information, database items, sequences and alarms to the operator workstation. JOHNSON CONTROLS: SCT Series software ADVANCED GRAPHICS MS-ADVGRF-0 Series software, or equal.

12.10.3 Application Controllers

12.10.3.1 Primary Application Controller

1. The primary application controller shall perform the function of monitoring all system variables, both from real hardware points, software variables, and controller parameters; JOHNSON CONTROLS: NAE Series, or equal.

2. The primary application controller shall manage and direct all information traffic on the Tier 1 network, between the Tier 1 and Tier 2 networks, and to the OWS.

3. The primary application controller shall be capable of direct connection to multiple field busses using different protocols simultaneously as indicated below. Should the controller not support multiple field busses, install two (2) primary controllers side by side.

    a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network. A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus. The NAE shall support a minimum of 100 BACnet control devices. ***The Conformance Statements shall be submitted 10 day prior to bidding.***

    b. The NAE shall support LonWorks enabled devices using the Free Topology Transceiver FTT10. All LonWorks controls devices shall be LonMark certified. The NAE shall support a minimum of 255 LonWorks enabled control devices.

    c. The NAE shall support the JOHNSON CONTROLS N2 Field Bus. The NAE shall support a minimum of 100 N2 control devices. The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485. The Bus shall employ a master/slave protocol where the NAE is the master.

    d. The Bus shall support the Metasys Integrator System including Modbus

4. The primary controller (NAE) shall have the capability to integrate data from all three (3) field busses into a common object structure. Data from all three (3) field busses shall appear in common displays throughout the user interface in exactly the same format.

5. A failure at a primary controller shall not cause failures or non-normal operation at any other system controller.

6. All primary controllers shall comply with the following standards: CSA C22.2 No. 205, FCC Part 15, Subpart J, Class A, UL 916, UL 864.

12.10.3.2 HVAC Controllers

1. HVAC controller shall provide both standalone and networked direct digital control; JOHNSON CONTROLS: VMA 1400 series, or equal, for reheat duct terminal units and duct coils. JOHNSON CONTROLS: AS-UNT100 Series and DX-9100 controllers, or equal, for air handlers and potable water system equipment. JOHNSON CONTROLS: TEC series, or equal, for unit heaters.

2. A dedicated HVAC controller shall be configured and provided for each air handler, fan, unit heater, zone heating coil, reheat terminal unit, Electric Fire Control Damper System.

3. Each HVAC controller shall retain program, control algorithms, and set-point information in non-volatile memory in the event of a power failure, and shall return to normal operation upon restoration of power.

4. Each HVAC controller shall report its communication status to the primary controller, and shall provide a system advisory upon communication failure and restoration.

5. For each primary HVAC system, provide a means to adjust set-points and start/stop equipment at, or adjacent to the HVAC controller. All digital outputs shall include three-position manual override switches to allow selection of “ON”, “OFF” or “AUTO” output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition, each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range.

6. <u>The VMA controller shall:</u>

   a. Utilize a proportional plus integration (PI) algorithm for the space temperature control loops.

b. Continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.

12.10.4 Field Devices

12.10.4.1 Input Devices

1. Air Differential Filter Pressure Sensor

    a. Provide each filter bank with a separate filter pressure sensor. NEMA 1 enclosure, Range: 0.05 to 5.0 inch WC, Output: 0-10Vdc, 4-20mA. Include complete installation kit including static pressure tips, tubing, fittings, and air filters; SETRA: DPT 200 series, or equal.

2. Filter Gauges

    a. Provide each filter bank with a separate filter gauge. Diaphragm type with dial and pointer in metal case, vent valves, "BLACK" figures on "WHITE" background with recalibration adjustment. Flush mounted with adjustable signal flag, Range: 0 to 2.0 inch WG., diameter: 4½ inches. Static-pressure tips, tubing, gage connections, and mounting bracket. DWYER: Series 2000 Magnahelic, or equal.

3. Room Temperature Sensors for EOS /Workshop areas, Pilothouses and Crew Quarters and Officer Quarters.

    a. Range: 32F to 122F degrees, Accuracy: ± 0.3F degrees at 70F degrees, Output: Resistive 1,000ohms @ 70F degrees, LCD display of room and outdoor air temperatures, 4-button keypad control for local user adjustment of room comfort set-point; JOHNSON CONTROLS: TMS 1600 series, or equal.

4. Room Temperature Sensors for all other areas

    a. Range: 55F to 85F degrees, Accuracy: ± 0.1%, Output: resistive 1,000ohms @ 70F degrees, standard wall mounting kit with metal guard. JOHNSON CONTROLS: TE 6000 series, or equal.

5. Duct / Pipe Temperature Sensors

    a. Nickel element in a copper tube, Range: -50F to 250F degrees, Accuracy: 0.1%, Output: Resistive 1,000ohms @ 70F degrees, duct

element holder, brass well assembly, bracket and cover; JOHNSON CONTROLS: TE 6000 series, or equal.

6. Current Switch

a. Provide each HVAC fan controlled from the HCS with a current switch, Materials: Encased copper, Rating: 600Vac, mounting: split core, Range: 1.5 to 50 Amps, Action: Trip-point adjustment, Output: SPST, N.O., Status LED. VERIS: H700 series, or equal.

7. Low Temperature Switches

a. Provide low temperature switches for each fan system. NEMA 1 enclosure, Mounting: duct insertion, Range: 15F to 55F degrees, Output: SPDT 120 Vac, 16 Amp, manual reset button, external manual set-point knob, auxiliary contact; JOHNSON CONTROLS: A70 series, or equal.

12.10.4.2 Controlled Devices

1. Control Valves

a. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Technical Specification.

b. Globe Valves

Materials: Cast Bronze Body, stainless steel trim, Valve Body Rating: ANSI B15.16, Class 250, Packing: spring loaded PTFE with Elastomer V-Rings, Rangeability: 25:1, Leakage: 0.05% of maximum flow, 2-Way valves equal percentage, 3-Way valves linear flow, Temperature Range: 35F to 250F degrees. Globe Valves shall be

used for all control valves over 1" in size; JOHNSON CONTROLS: VG 7000 series, or equal.

c. Ball Valves

Materials: Forged Brass Body, Stainless Steel Ball and Stem, Valve Body Rating: 580 psig,, Maintenance–Free Design with no packings to adjust and no periodic rebuilding required, EPDM double O-ring stem seal, graphite reinforced PTFE Seats backed with EPDM O Rings, Rangeability: 500:1, Leakage: 0.01% of Maximum Flow, 2-Way Valves Equal Percentage, 3-Way Valves Linear Flow, Temperature Range: -22F to 284F degrees. Ball Valves shall be used for all control valves 1" in size or less; JOHNSON CONTROLS: VG 1000 series, or equal.

2. Automatic Temperature Control Dampers

Stainless Steel Blade/Frame/Bearing/Seals, Rating: 7 CFM Max. at 1-inch static pressure, Class 2 leakage resistant, stainless steel construction, Temperature Rating: -25F to 180F degrees; JOHNSON CONTROLS: VD 1600 series, or equal.

3. Electric Volume Damper and Valve Actuators

Direct mount, ninety (90) seconds end to end full stroke, electronic stall protection. Control Input: 0-10 Vdc or 0-20 mAdc, Torque: Size for minimum 150-percent (150%) of required duty, Duty Cycle: rated for 65,000 cycles, output position feedback, manual override, field selectable rotational / spring return direction, field adjustable zero and span; JOHNSON CONTROLS: M9000 series, or equal.

Provide NEMA 3R weather shield covers for all actuators exposed to direct outside air for protection of the electric actuator from corrosion, rain, freezing rain, sleet, and snow. Weather shields shall include a transparent cover to provide an unobstructed view of the electric actuator without having to disassemble the enclosure. An appliance cord shall enable installation of control wiring, and a form-fitting seal prevents water or moisture from entering the unit and damaging the actuator. JOHNSON CONTROLS M9000-320 or equal direct mount, 90 seconds end-to-end full stroke, electronic stall protection, Control Input: 0-10 Vdc or 0-20 mAdc, Torque: Size for minimum 150-percent (150%) of required duty, Duty Cycle: rated for 65,000 cycles, output position feedback, manual

override, field selectable rotational / spring return direction, field adjustable zero and span; JOHNSON CONTROLS: M9000 series, or equal.

4. Self-Contained Thermostatic Control Valves

Provide one (1) valve for each hot water wall convector. Materials: bronze body, stainless steel stem, Rating: 15 PSID close-off, 230 PSIG body, Sensor: Liquid filled sensing element in accordance with DIN Standard No. 3841. Actuator: proportionally regulating, Temperature Range: 36F to 277F degrees, manual adjustment knob, 26 foot sensing element. MNG Model, or equal.

5. Panel Enclosures

Provide enclosure for each Primary Controller and each HVAC Controller utilized for Air Handling Units. Enclosure shall be UL 508A rated control panel with screw terminals, re-settable circuit breaker and transformer. Enclosures shall be pre-built, pre-wired, and pre-tested in an ISO 9002 manufacturing facility.

12.10.5 Performance / Execution / Closeout

12.10.5.1 Installation Description

All conduit, wiring, accessories and installation of devices required for the installation of the HVAC Control System, as herein specified, shall be provided by the Shipyard Contractor under the direction and supervision of the HCS contractor. All wiring and installation practices shall comply with the Technical Specifications and HCS manufacturers recommendations.

The sizing and type of cable, conduit, cable trays, and raceways shall be the design responsibility of the HCS Contractor and meet the requirements of the Technical Specification.

The HCS Contractor shall provide all final terminations at all control devices.

The Shipyard Contractor shall perform circuit tests using manufacturers certified personnel only and shall provide necessary instruments and equipment to demonstrate that: All circuits are continuous and free from short circuits and grounds; All circuits are free from unspecified grounds; resistance to ground of

all circuits is no less than fifty (50) mega ohms and, all circuits are free from induced voltages.

12.10.5.2 Training

The HCS contractor shall provide eight (8) hours of on-site, Vessel specific orientation/training for each Vessel by a manufacturers certified system technician who is fully knowledgeable of the specific installation details of the project. Provide forty (40) hours of training for twenty (20) WSF personnel in the manufacturers factory-training lab. The training plan shall be developed in conjunction with WSF to meet the unique requirements of WSF personnel. A factory-certified professional trainer shall perform the training. See the *TRAINING OF WSF PERSONNEL* Subsection in Section 1 of the Technical Specification.

12.10.5.3 Commissioning

Fully commission all aspects of the HCS work. ***1).*** Prepare a Test memorandum that includes all points for all functions of the HCS, and meets the requirements of the *TEST PROCEDURES* and *Heating, Ventilation And Air Conditioning* Subsections of Section 101 of the Technical Specification; ***2).*** Submit the test memorandum to the WSF Representative for approval one (1) month prior to testing; ***3).*** Complete the test memorandum for all items and functions of the HCS and initial each entry with time/date as record of having fully calibrated and tested the HCS; ***4).*** Submit the test memorandum to WSF. The WSF Representative will use the test memorandum as the basis for acceptance testing with the HCS Contractor. The HCS Contractor shall test each dual duct terminal unit box. The dampers in one-half (½) of a group of boxes shall be stepped towards full open while the other half are stepped towards full closed. At each step, after a settling time, box air flows and damper positions will be sampled. Following the cycle, a pass/fail report indicating results shall be produced. Possible results are “Pass”, “No change in flow between full open and full close”, “Reverse operation or Maximum flow not achieved”. The test memorandum shall be submitted as documentation of the installation. The HCS Contractor shall issue a test memorandum based on a sampling of the terminal units calculated loop performance metrics. The test memorandum shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance. The test memorandum sampling shall take place after completion of Test and Balance, when design cooling and heating media have been available and occupied conditions approximated for five (5) consecutive days.

12.10.5.4 Software Update

The HCS software residing in controllers and operator workstations shall be updated to the latest currently available revision at the start of the Warranty period. In addition, the HCS software residing in controllers and operator workstation for all four (4) Vessels shall be updated to the latest currently available revision at the start of Warranty for the final Vessel in the Contract so all four (4) Vessels will have the identical version of the most current version of software.

12.10.6 Sequence of Operation

12.10.6.1 Exhaust and Supply Fans

All Exhaust and Supply fans shall be controlled from the HCS system. Provide fan status from current switch for all fans controlled from HCS system.

12.10.6.2 Terminal Reheat Air Conditioning Systems

a. SYSTEM OFF:

The supply fan shall be "off". The outside air damper shall be closed and return air dampers shall be set in a fixed position. The heating coil valve shall be "closed". The DX cooling compressor shall be "off".

b. SYSTEM RUN:

Supply fan shall run continuously. If the supply fan status does not match the commanded value, an alarm will be generated. when the supply fan status indicates the fan started, the control sequence will be enabled. The outside air damper and return air damper shall open to a fixed position. The heating valve will modulate and the DX cooling coil will cycle in sequence to maintain the discharge air temperature at set-point.

c. SAFETY:

All of the safety devices are manual reset; the device that has tripped must be manually reset before restarting the air handling unit.

1. If a temperature low limit switch senses a temperature below set-point the supply fan will be shutdown and an alarm signal shall be sent to the HCS.
2. If a fire alarm shutdown contact is provided, the supply fan will be shutdown when triggered.

d. SHUTDOWN:

When the unit is shutdown by either a stop command or system safety the unit will be set as follows:

1. Supply fan will be off
2. Outside air damper will close
3. Return air damper will open
4. Heating valve will close

12.10.6.4 Multi-Zone Heating and Ventilation Systems

a. SYSTEM OFF:

The supply and return fans shall be "off". The outside air and exhaust air dampers shall be closed and the return air damper shall be "open". The zone hot water heating coil valves shall be "closed".

b. SYSTEM RUN:

Winter Heating Mode and Summer Cooling Mode shall be automatically determined by outside air temperature and manually adjustable.

1. Winter Heating Mode:

Supply and return fans shall run continuously on low speed. Outside air and exhaust air dampers shall be positioned to

33-percent (33%) open and return air damper shall be 66-percent (66%) open (adjustable). When the associated air handling system is started, zone heating coil control valves shall be permitted to control to set-point. Zone Hot Water Heating Coil control valves shall be modulated to maintain space temperature sensor set-point. Provide duct mounted discharge air temperature sensor downstream of each zone heating coil for monitoring and troubleshooting. Set-point shall be adjusted remotely from HCS or locally from thermostat.

2. Summer Cooling Mode:

Supply and return fans shall run continuously on high speed. Outside air and exhaust air dampers shall be positioned to 100-percent (100%) open and return air damper shall be 100-percent (100%) closed (adjustable). Zone hot water heating control valves shall be "closed".

12.10.6.5 Wall Convectors - Hot Water

A self-contained thermostatic control valve shall modulate to maintain space temperature set-point. Set-point shall be adjusted from local thermostat.

12.10.6.6 Unit Heaters - Hot Water

Heating coil control valve and fan shall cycle to maintain space temperature set-point from dedicated networked and stand-alone HVAC controller. Set-point shall be adjusted remotely from HCS or locally at controller.

12.10.6.7 Typical Safeties and Alarms for HCS System

a. Manual reset low limit thermostat shall stop the supply and return fans, close the heating coil valves, de-energize the DX cooling coil and annunciate alarm at HCS should the fan discharge air temperature fall below 38F degrees.

b. Filter Condition: Monitor differential pressure across filter and annunciate alarm when differential pressure set-point (adj.) is exceeded. Provide an additional local filter gauge for local indication of filter status.

c. Annunciate off normal alarms whenever supply fan status does not equal command.

d. Annunciate alarms when any space, pipe and duct temperature exceeds minimum and maximum limits.

Local automatic and/or manual controls shall be provided as described in this Section and Section 91 of the Technical Specification for unit heaters, convectors in the Deck Crew Shelter, and all fans serving Steering Gear Rooms, Voids, Tank Rooms, Machinery Space Fire Protection Room, Paint Lockers, Elevator Trunks, Gear Lockers, Toilet Exhausts and Sewage Tank Vents.

All changeover dampers (outside, return, and exhaust) shall be the multi-blade type, operated by the HVAC System Master Controller.

Automatically operated dampers (outside, return and exhaust) for multi-zone heating and ventilation systems shall change between two (2) positions (100-percent (100%) fresh air for cooling, and the minimum fresh air for heating). Damper stops shall be set to ensure minimum design fresh (outdoor) air requirements. A manually-operated diverting switch shall be provided so that the changeover dampers may be properly controlled in the event of a failure of the automatic controls.

12.11 VENTILATION INSULATION AND LAGGING

All parts of ventilation, heating and air conditioning systems (including equipment, access covers, flanges and recirculation ducts) shall be insulated in accordance with Sections 7 and 75 of the Technical Specification, and **TABLE 12-8** below:

TABLE 12-8

Insulation and Lagging Requirements

System Description	Insulation Requirement
Air Conditioning	Insulate one (1) inch thick, vapor seal and lag completely
Recirculation Systems	Except for fans and within areas served, insulate one (1) inch thick. Lag exposed insulation. Vapor seal and lag in hot or wet areas.
Ventilation Supply Systems	Insulate one (1) inch thick, except within areas served. Lag exposed insulation. Vapor seal and lag in hot or wet areas.
Ventilation Exhaust Systems	Insulate one (1) inch thick where system serves unheated or heat producing spaces and passes through heated or air conditioned spaces.
Portions of Air Conditioning, Re-Circ or supply ducts in the Uptakes	Insulate one (1) inch thick, vapor seal and lag.
Ventilation Supply and Exhaust Systems serving Steering Gear Rooms, Voids. Sewage Tank Vents, Reduction Gear Rooms, and Tank Rooms	None required.

Ventilation ducting serving only the space in which it is located need not be insulated.

Insulation shall be thick fibrous glass board with minimum density of three (3) pounds per cubic foot (3 lbs./ft^3) for rectangular duct. Insulation on round or flat-oval ducts and bends shall be flexible fibrous glass with a minimum density of 1½ pounds per cubic foot (1.5 lbs./ft^3). Vapor barrier shall be factory-applied aluminum foil, at least 0.002 inch thick. All joints in the vapor barrier shall be overlapped a minimum of two (2) inches and coated with an approved vapor sealing compound.

Insulation shall be secured to the duct with an approved adhesive. On rectangular ducts over twenty-four (24) inches wide, equipment and plenums, insulation shall be further secured with metal clips, pins or studs. Any insulation applied to the inside of ducting shall be specifically designed for that purpose and shall be suitably installed to ensure adherence.

All materials used for insulation must comply with 46 CFR §164.007, §164.009, or §164.012-5c as appropriate.

In areas where insulation may be subject to damage, protection such as galvanized metal sheathing or guards, shall be provided. Metal sheathing thickness shall be at least 16 USSG.

12.12 ACOUSTIC INSULATION

Acoustic treatment and insulation treatments, as described in this Section of the Technical Specification, shall be provided in the ventilation system as required to limit noise in the accommodation spaces to the levels specified in Section 102. Internal duct lining shall consist of one (1) inch or two (2) inch fibrous glass insulation, as appropriate, faced with reinforced Mylar exposed to the air flow. The treatment shall be covered on the air side with #16 USSG perforated metal. As alternates, commercial duct silencers and/or approved sound trap boxes at diffuser terminals may be installed.

To decrease transmission of noise through ducts, and to allow for relative motion between the resiliently mounted ventilation fans and the ducts, flexible joints shall be installed at the suction and discharge of all ventilation fans and blowers. Size and material of the flexible joints shall be such that the length of the flexible duct is a minimum of twelve (12) inches and the wall thickness is a minimum of $^{3}/_{16}$ inch. Flexible duct connections shall be flanged rubber spools of 40 durometer hardness maximum.

Where both thermal and acoustic insulation is applied, credit may be taken for the thermal value of the acoustic insulation.

All insulation shall be provided, installed, and painted as set forth in this Section, Section 7, and Section 14 of the Technical Specification.

12.13 CLEANING

Clean all ductwork, heating coils, and fans after installation and prior to Vessel delivery. Thoroughly vacuum and hot-water-clean the interiors to remove dirt and grease.

After all work, cleaning and testing is complete and just prior to delivery, provide new filters for all systems and provide an additional 100-percent (100%) of spare replacements to the WSF Representative.

12.14 SPARE PARTS AND INSTRUCTION MANUALS

Provide a list of recommended spare parts and special tools for those items that are Contractor furnished, together with parts lists and instruction manuals necessary to maintain and service provided equipment and accessories in accordance with the requirements of Sections 86 and 100 of the Technical Specification.

12.15 TESTS, TRIALS AND INSPECTIONS

Test and balance each duct system for leaks in the presence of the WSF Representative in accordance with this Section of the Technical Specification and Reference (12E). Repair any leak, unbalance, or discrepancy found and retest the system.

Balance each ventilation zone independently. Balance all systems so that the delivered quantity of air to each compartment is plus or minus 5-percent (±5%) and to each terminal, diffuser, etc., is plus or minus 10-percent (±10%) of design value shown on the WSF approved ventilation drawing, which the Contractor shall prepare. Demonstrate satisfactory air tightness and balance of each system prior to the concealment of ductwork, and with scaffolding available.

Submit a report of the air balancing results to the WSF Representative. Identify the instrumentation used, calibration date and final air quantities at each terminal in the report.

Tests and/or trials of air conditioning, heating and ventilation systems shall be in accordance with this Section and Section 101 of the Technical Specification.

Inspections shall be performed as defined in this Section and Section 1 of the Technical Specification.

12.16 PHASE II TECHNICAL PROPOSAL REQUIREMENTS

The following schematic and calculations, in addition to other deliverables required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase II Technical Proposal stage of Work in accordance with the requirements of Section 100 of the Technical Specification:

A. Preliminary HVAC Duct Sizing and Pressure Loss Calculations

B. HVAC Controls Schematic

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

12.17 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS

The following report and calculations, in addition to other deliverables required by Section 100 of the Technical Specification and the Authoritative Agencies shall be provided during the Phase III Detail Design stage of Work in accordance with the requirements of Section 100 of the Technical Specification:

A. HVAC Duct Sizing and Pressure Loss Calculations

B. Air Balancing Report

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

(END OF SECTION)